Mathematical Statistics
Stockholm University
Research Report **2017:13**,
http://www.math.su.se

Towards a flexible statistical modelling by latent factors for evaluation of simulated responses to climate forcings: Part II

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October 2017

Abstract

Evaluation of climate model simulations is a crucial task in climate research. In a work consisting of three parts, we propose a new statistical framework for evaluation of simulated responses to climate forcings, based on the concept of latent (unobservable) variables. In Part I, several latent factor models were suggested for evaluation of temperature data from climate model simulations, forced by a varying number of forcings, against climate proxy data from the last millennium. Here, in Part II, focusing on climatological characteristics of forcings, we deepen the discussion by suggesting two alternative latent variable models that can be used for evaluation of temperature simulations forced by *five specific* forcings of natural and anthropogenic origin. The first statistical model is formulated in line with *confirmatory factor analysis* (CFA), accompanied by a more detailed discussion about the interpretation of latent temperature responses and their mutual relationships. Introducing further *causal links* between some latent variables, the CFA model is extended to a *structural equation model* (SEM), which allows us to reflect more complicated climatological relationsnhips with respect to all SEM's variables. Each statistical model is developed for use with data from a single region, which can be of any size. Associated with different hypotheses, the CFA and SEM models can, as a beginning, be fitted to observable simulated data only, which allows us to investigate the underlying latent structure associated with the simulated climate system. Then, the best-fitting model can be fitted to the data with real climate proxy data included, to test the consistency between the latent simulated temperature responses and their real-world counterparts embedded in observations. The performance of both these statistical models and some models suggested in Part I is evaluated and compared in a numerical experiment, whose results are presented in Part III.

Keywords: Confirmatory Factor Analysis, Structural Equation models, Measurement Error models, Climate model simulations, Climate forcings, Climate proxy data, Detection and Attribution

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